Executive Summary

The City of San Diego (City) conducts an extensive ocean monitoring program to evaluate potential environmental effects from the discharge of treated wastewater to the Pacific Ocean via the South Bay Ocean Outfall (SBOO). The data collected are used to determine compliance with receiving water conditions as specified in NPDES regulatory permits for the City's South Bay Water Reclamation Plant (SBWRP) and the International Wastewater Treatment Plant (IWTP) operated by the U.S. International Boundary and Water Commission (USIBWC). Since treated effluent from these two facilities commingle before being discharged to the ocean, a single monitoring and reporting program approved by the San Diego Regional Water Quality Control Board and U.S. EPA is conducted to comply with both permits.

The primary objectives of the ocean monitoring efforts for the South Bay outfall region are to: (a) measure compliance with NPDES permit requirements and 2005 California Ocean Plan (Ocean Plan) water-contact standards, (b) monitor changes in ocean conditions over space and time, and (c) assess any impacts of wastewater discharge or other man-made or natural influences on the local marine environment, including effects on water quality, sediment conditions and marine life. Regular fixed monitoring sites that are sampled on a weekly, monthly, quarterly or semiannual basis are centered around the SBOO discharge site located approximately 5.6 km offshore at a depth of 27 m. Shoreline monitoring extends from Coronado, San Diego (USA) southward to Playa Blanca in northern Baja California (Mexico), while regular offshore monitoring occurs in adjacent waters overlying the continental shelf at depths of about 9 to 55 m.

Prior to the initiation of wastewater discharge though the SBOO in 1999, the City conducted a 3½ year baseline study designed to characterize background conditions in the region. In addition to regular fixed-site monitoring, a broader regional survey of benthic conditions is conducted each year at randomly selected sites that range from northern San Diego County to the USA/Mexico border and that extend further offshore to waters as deep as 500 m. These regional surveys are useful for evaluating patterns and trends over a larger geographic area, and thus provide additional information for distinguishing reference from impact areas.

The results and conclusions of all ocean monitoring activities conducted for the South Bay outfall monitoring program from January through December 2011 are organized into nine chapters in this report. Chapter 1 presents a general introduction and overview of the ocean monitoring program, while chapters 2–7 include results of all fixed site monitoring conducted during the year. In Chapter 2, data characterizing oceanographic conditions and water mass transport for the region are evaluated. Chapter 3 presents the results of shoreline and offshore water quality monitoring, including measurements of fecal indicator bacteria to determine compliance with Ocean Plan standards. Assessments of benthic sediment quality and the status of macrobenthic invertebrate communities are presented in Chapters 4 and 5, respectively. Chapter 6 presents the results of trawling activities designed to monitor communities of bottom dwelling (demersal) fishes and megabenthic invertebrates. Bioaccumulation assessments to determine contaminant loads in the tissues of local fishes are presented in Chapter 7. Results of the summer 2011 San Diego regional survey of sediment conditions and benthic macrofaunal communities are presented in Chapters 8 and 9, respectively. In addition to the above activities, the City and USIBWC support other projects relevant to assessing the quality and movement of ocean waters in the region. One such project involves satellite imaging of the San Diego/Tijuana coastal region, the results for 2011 which are incorporated into Chapters 2 and 3. A summary of the main findings for each of the above components is included below.

Oceanographic Conditions

Oceanographic data collected in the South Bay outfall region support reports that describe 2011 as a La Niña year characterized by the early onset of relatively strong upwelling. Conditions indicative of local upwelling were most evident during March and June. Additionally, satellite images revealed colder-than-normal sea surface temperatures during the summer as would be expected during a La Niña. As is typical for the area, maximum stratification (layering) of the water column occurred in mid-summer, while well-mixed waters occurred during the winter. The only indication of the wastewater plume from the oceanographic data was relatively low salinity and high CDOM values measured near the discharge site. Changes in dissolved oxygen concentrations, pH and water clarity (transmissivity) relative to wastewater discharge were not discernible. Satellite imagery results indicated that the plume reached near-surface waters directly over the discharge site from January through March and from mid-October through December when the water column was not strongly stratified. Satellite observations also showed the furthest extent of the visible plume to be ~700 meters from the discharge area, thus supporting conclusions that inshore plume dispersion is minimal. In contrast, the plume remained deeply submerged from April through September when water column stratification was greater. Overall, ocean conditions during the year were consistent with well documented patterns for southern California and northern Baja California. These findings suggest that natural factors such as upwelling of deep ocean waters and effects of widespread climatic events such as El Niño/La Niña oscillations continue to explain most of the temporal and spatial variability observed in the coastal waters off southern San Diego.

Water Quality

There was no evidence that the SBOO wastewater plume reached nearshore recreational waters in 2011. Although elevated levels of fecal indicator bacteria (FIB) were detected along or near the shore, this did not appear related to shoreward transport of the plume. Instead, most nearshore bacterial contamination was rainfall related and associated with turbidly plumes resulting from increased outflows from the Tijuana River (USA) and Los Buenos Creek (Mexico) during and after storm events. For example, about 88% of all elevated FIBs at the shore and kelp stations occurred during the wet season. This relationship between increased rainfall and high FIB counts in local waters has remained consistent since monitoring began several years prior to wastewater discharge. Most elevated FIB counts reported during the dry season occurred south of the international border at shore stations located near other sources of contamination not associated with the SBOO. In contrast, only a single sample with elevated FIBs was collected near (within 1000 m) of the SBOO discharge zone during the year. The overall low incidence of contaminated waters related to the SBOO plume is likely due to continued seasonal disinfection and the commencement of full secondary treatment at the IWTP in early 2011.

Overall compliance with the 2005 Ocean Plan standards was 91% in 2011, which was slightly higher than the 87% compliance observed in 2010. Compliance with the total coliform, fecal coliform and enterococcus geometric mean standards ranged from 59% to 100% at the shore stations and from 92% to 100% at kelp stations. Compliance with the four single sample maximum standards ranged from 87% to 91% at the shore stations, and from 98% to 99.5% at the kelp stations. Since compliance rates reflect the presence of elevated FIBs, compliance was generally lowest during the wet season (January–April, November–December) when rainfall was greatest.

Sediment Conditions

The composition of benthic sediments at the regular SBOO stations was similar in 2011 to previous years and varied from fine silts to very coarse sands or other large particles. There was no

apparent relationship between sediment grain size distributions and proximity to the discharge site, nor has there been any substantial increase in fine sediments near the outfall or throughout the region since wastewater discharge began. Instead, the range of sediment types present reflects multiple geological origins or complex patterns of transport and deposition from sources such as the Tijuana River and San Diego Bay.

Sediment quality in the region was also similar in 2011 to previous years with overall contaminant loads remaining low compared to other southern California coastal areas. There was no evidence of contaminant accumulation associated with wastewater discharge. Concentrations of the various organic loading indicators, trace metals, pesticides and PCBs varied widely throughout the region, and there were no patterns that could be attributed to the outfall or other point sources. Instead, the distribution of contaminants in sediments continued to be linked to natural environmental heterogeneity. For example, concentrations of total organic carbon, total nitrogen, total volatile solids, and several metals were usually higher at sites characterized by finer sediments, a pattern consistent with results from other studies. Finally, the potential for environmental degradation by the various contaminants was evaluated using the effects-range low (ERL) and effects-range median (ERM) sediment quality guidelines when available. The only exceedances of either threshold in 2011 were for arsenic, which exceeded the ERL at one station during the January and July surveys.

Macrobenthic Communities

Benthic macrofaunal assemblages surrounding the SBOO were similar in 2011 to previous years, and there were no significant differences between those occurring at nearfield and farfield sites. These assemblages were typical of those that occur in similar habitats throughout the Southern California Bight (SCB). For example, most of the relatively shallow, coarse sand sites had high abundances of *Spiophanes norrisi*, a polycheate worm characteristic of similar habitats throughout the SCB. In contrast, slightly different assemblages were found at mid-depth stations with somewhat finer sediments characteristic of much of the southern California mainland shelf.

Species richness and total abundance of the SBOO macrobenthic assemblages varied with depth and sediment type, but showed no clear patterns relative to the discharge area. Instead, spatial patterns in abundance were driven mostly by changes in *S. norrisi* populations similar to that observed in 2010. Benthic response index (BRI) values were also mostly characteristic of non-impacted macrofaunal communities. Additionally, changes that did occur during the year were similar in magnitude to those seen previously in southern California waters, and correspond to large-scale oceanographic processes or other natural events. Overall, macrofaunal assemblages in the region remain similar to indigenous communities characteristic of similar habitats on the southern California continental shelf. There was no evidence that wastewater discharge has caused degradation of the marine benthos in the region.

Demersal Fishes And Megabenthic Invertebrates

Speckled sanddabs dominated fish assemblages surrounding the SBOO in 2011 as they have in previous years, occurring at almost all stations and accounting for 66% of the total year's catch. Other species collected in at least half the trawls included yellowchin sculpin, longspine combfish, English sole, roughback sculpin, California tonguefish, and longfin sanddab. Although the composition and structure of fish assemblages varied among stations, these differences were mostly due to natural variation in populations of speckled sanddab, California lizardfish, white croaker, yellowchin sculpin and English sole.

Trawl-caught invertebrate assemblages were dominated by the sea star *Astropecten californicus*, which occurred in almost all trawls and accounted for 35% of the total invertebrate abundance. Other

less abundant but common species included the parasitic isopod *Elthusa vulgaris*, the crab *Metacarcinus gracilis*, the nudibranch *Acanthodoris brunnea*, the opisthobranch *Pleurobranchaea californica,* and the octopus *Octopus rubescens*. As with fishes, the composition and structure of the invertebrate assemblages varied among stations, reflecting mostly large fluctuations in populations of the above species.

Comparisons of the 2011 trawl survey results with previous surveys (1995–2010) indicate that demersal fish and megabenthjic invertebrate communities in the region remain unaffected by wastewater discharge. The relatively low species richness and small populations of trawl-caught fishes and invertebrates are consistent with the shallow, sandy habitat surveyed. Patterns in the abundance and distribution of individual species were similar at stations located near the outfall and farther away, suggesting a lack of significant anthropogenic influence. Finally, external examinations of all fishes captured during the year indicated that local fish populations remain healthy, with there being no evidence of physical anomalies or disease.

Contaminants In Fish Tissues

The accumulation of contaminants in marine fishes may be due to direct exposure to contaminated water or sediments or to the ingestion of contaminated prey. Consequently the bioaccumulation of chemical contaminants in local fishes was assessed by analyzing liver tissues from trawl-caught fishes and muscle tissues from species captured by hook and line. Results from both analyses indicated no evidence to suggest that contaminant loads in fishes captured in the region were affected by wastewater discharge in 2011. Although a few tissue samples contained metal concentrations that exceeded pre-discharge maximums or international standards, concentrations of most contaminants were generally similar to that observed prior to discharge. Additionally, tissue samples that did exceed pre-discharge contaminant levels were found in fishes from sites that were widely distributed throughout the region. Furthermore, all contaminant concentrations were within ranges reported previously for southern California fishes.

The occurrence of some metals and chlorinated hydrocarbons in local fishes may be due to many factors, including the ubiquitous distribution of many contaminants in southern California coastal sediments. Other factors that affect the bioaccumulation of contaminants in fish include the different physiologies and life history traits of various species. Additionally, exposure to contaminants can vary greatly between fish species and even among individuals of the same species depending on migration habits. For example, a fish may be exposed to contaminants in a polluted area and then migrate to a region that is less contaminated. This is of particular concern for fishes collected in the vicinity of the SBOO, as there are many other point and non-point sources that may contribute to contamination.

San Diego Regional Survey

The summer 2011 San Diego regional benthic survey covered an area ranging from offshore of Del Mar south to the USA/Mexico border. A total of 41 randomly selected sites were sampled at depths ranging from 10 to 427 m and that spanned four distinct depth strata (i.e., inner shelf, mid-shelf, outer shelf, upper slope). Included below is a summary of the sediment conditions and soft-bottom macrobenthic assemblages present during the 2011 survey, along with a comparison to conditions present during 2009 and 2010 for a three-year assessment.

Regional Sediments

The composition of sediments at the regional stations sampled in 2011 was typical for continental shelf and upper slope benthic habitats off southern California, and consistent with results from previous surveys. Overall, sediment types varied as expected by region and depth. For example, stations sampled within the regular SBOO fixed-station grid tended

to have sediments composed predominantly of sand, whereas stations sampled within the regular Point Loma Ocean Outfall (PLOO) monitoring grid tended to have much finer sediments dominated by silts and clay. Exceptions to this pattern did occur, particularly at outer shelf sites located along the Coronado Bank, a southern rocky ridge located southwest of Point Loma. Sediment composition in this area is generally coarser than stations located at similar depths west of Point Loma and further to the north.

As with grain size composition, the quality of regional sediments sampled in 2011 was similar to previous years, and there was no evidence of degraded sediment quality. While various organic loading indicators trace metals, chlorinated pesticides, PCBs and PAHs were detected, contaminant concentrations were relatively low compared to many other coastal areas of the SCB. Almost all contaminants occurred at levels below ERL and ERM thresholds. Further, although contaminant concentrations in San Diego sediments have been highly variable over the past three years, there was no evidence of disturbance that could be attributed to local wastewater discharges from either the SBOO or the PLOO. Instead, concentrations of total nitrogen, total volatile solids and several trace metals were found to increase with increasing amounts of fine sediments (percent fines). As percent fines also increased with depth, many contaminants were detected at higher concentrations in deeper strata compared to shallower inner and mid-shelf regions. For example, the highest levels of most contaminants were found in sediments along the upper slope where some of the finest sediments occurred.

Regional Macrofauna

The SCB benthos has long been considered to be composed of heterogeneous or "patchy" habitats, with the distribution of invertebrate species and communities exhibiting considerable spatial variability. Results of the summer 2011 regional survey, coupled with data from 2009 and 2010, support this characterization, with the major assemblages segregating by habitat characteristics such as depth and sediment type.

The inner to mid-shelf macrofaunal assemblages off San Diego were similar to those found in other shallow, sandy habitats across the SCB, and were characterized by species such as the polychaete worms *Owenia collaris* and *Spiophanes norrisi*, and the bivalve *Tellina modesta*. Assemblages occurring in somewhat finer but more mixed sediments at mid- to outer shelf depths were dominated by the brittle star *Amphiodia urtica*, and corresponded to the *Amphiodia* "mega-community" described previously for the SCB. Although also occurring at outer shelf depths, coarser sediment sites along the Coronado Bank were instead dominated by several other distinct species of polychaetes (e.g., *Aphelochaeta glandaria* Cmplx*, Monticellina siblina, Chaetozone* sp SD5). Upper slope habitats were characterized by species assemblages characteristic of much finer sediments that are distinct from most shelf areas. These upper slope assemblages were often characterized by relatively high abundances of specific bivalves (e.g., *Yoldiella nana*, *Nuculana conceptionis,* and *Tellina carpenteri*), as well as the presence of a few distinctive polychaetes (e.g., *Spiophanes kimballi* and *Maldane sarsi*)

Although benthic communities off San Diego vary across depth and sediment gradients, there was no evidence of disturbance during the 2009−2011 regional surveys that could be attributed to wastewater discharges, disposal sites or other point sources. Benthic habitats appear to be in good condition throughout the region, with 90% of the sites surveyed in 2011 being in reference condition based on assessments using the benthic response index (BRI). This pattern is consistent with recent findings for the entire SCB mainland shelf.

Conclusions

The findings and conclusions for the ocean monitoring efforts conducted for the South Bay outfall region during calendar year 2011, as well as

the summer 2011 San Diego regional benthic survey, were consistent with previous years. Overall, there were limited impacts to local receiving waters, benthic sediments, and marine invertebrate and fish communities. There was no evidence that the wastewater plume from the SBOO reached recreational waters during the year. Although elevated bacterial levels did occur in nearshore areas, such instances were largely associated with rain driven outflows from local rivers and creeks and not to shoreward transport of the plume. There were also no outfall related patterns in sediment contaminant distributions, or in differences between the various macrobenthic invertebrate and fish assemblages. The lack of disease symptoms in local fish populations, as well as the low level of contaminants detected in fish tissues, was also indicative of a healthy marine environment. Finally, results of the regional benthic survey conducted during the year also revealed no outfall related effects, and that benthic habitats in the region remain in good condition similar to much of the southern California continental shelf.